Small Scale Disturbance in Longleaf Stands from Lightning.

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As moist air rises in thunderstorm clouds and is carried to heights of 35,000 to 60,000 feet, ice crystals form in the cold of the upper atmosphere. We still do not know precisely how, but somehow collisions between rising and sinking ice crystals cause a separation of electrical charges. Positive charged ice collects at the top and negatively charged at the middle and lower portions of the storm cloud. As pool of positively charged particles gathers below the cloud along the ground. Once the charge reaches a threshold level, the cloud sends out a rapidly descending, but invisible to humans, stepped leader. This leader descends in a series of zigzag segments about 150 ft long toward the ground. A balancing pool of positive charged particles rises up from the ground on trees, buildings, poles or even people. When the stepped leader from the cloud gets within 150 ft of the ground a streamer of positive charges rises to meet it, a continuous channel is created and the return stroke charge surges upward setting off the brightly lit display we call lightning. The entire process from initiation of the step leader until the flash is gone takes less than a second. In this short time the channel super heats the surrounding air to five times the temperature on the surface of the sun. The rapid expansion of this super heated air causes thunder.

This scenario plays out numerous days each year in the southern U.S., especially in Florida, which is the lightning capital of North America. A small percentage of these lightning strokes are a special kind with longer duration that can heat material on the ground enough to start a fire. The longleaf pine ecosystems were once very common across the south from Virginia to Texas. Longleaf pine evolved with and is adapted to the lightning ignited fires that burned much of the region on a 1 to 5 year cycle. Lightning also impacts longleaf stands on a more local scale by killing trees. For 10 years Kenneth Outcalt has been studying the impacts of such lightning on longleaf pine stands on the Ocala National Forest.

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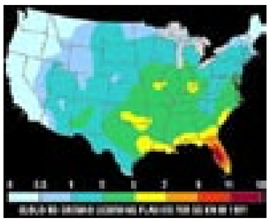
The average annual reported lightning density for this region of Florida is 10 to 12 /km2. In my stands, the density was nearly twice this at 23-strikes/ km2/yr. This means the Ocala National Forest has an extremely high occurrence of lightning. It is not surprising therefore that lightning was the major cause of tree death in longleaf pine stands I studied, killing 70 percent of all trees that died during the ten year period. In this region of high lightning, it removes 30 trees/km2 each year. Prescribed burning kills the fewest trees at just 2 trees/km2/yr. Actually, lightning very rarely directly kills trees. It only happened twice on the 80 hectares of my study. More commonly, the heat from the lightning causes the water and air in the conducting tissue of the stem to expand rapidly. This rapid expansion cause cell walls to break and often blows bark and wood from the tree trunk. This tree damage sends out turpenes that alert resident bark beetles of the injury. The mass attack of beetles combined with mechanical damage from the lightning usually results in death. Occasionally, however a tree will recover, which happened once in my study.

Because weather is variable, so is lightning. The lowest activity occurred in 1996 when yearly mortality rate was just 12 trees/km2. The highest rate was nearly four times greater at 45 trees/km2 in 1999. Because summer months are most favorable for thunderstorm development and therefore lightning, the months of June to September had the highest average lightning caused tree mortality. This also varied a lot with some years most occurring in June and other years a lot of lightning in August.

My work confirms the standard safety advice of avoiding tall objects during thunderstorms. The tallest trees in the stands had a much higher probability of being hit by lightning than did the shorter trees. Sometimes, however lightning would strike a short tree surrounded by taller ones. The effect of taller objects only



operated over a short scale. Trees in low regions within the stands received just as many strikes as those growing on the hills, or topography did not matter. The phrase, often used in a different context, that lightning doesn't strike twice in the same place, is clearly wrong as applied to real lightning. Two trees killed by lightning early in the study were hit a second time after they became dead snags.

Trees killed by lightning over the ten-year period were clumped within stands. Lightning often spreads or splinters into multiple leaders near the ground. Over 20 percent of all strikes in my stands were this type, which resulted in the simultaneous hit of 2 to 4 trees in a group. In addition, 50 percent of all trees hit by lightning were on the edge of an existing stand gap. Thus, 70 percent of all strikes created or enlarged gaps within the stand. All of these attributes combine to significantly shorten the time required to create opening large enough for longleaf pine regeneration, i.e. at least 0.1 ha (0.25 ac), from decades to 5 or 10 years.

As mentioned previously, lightning is the natural source of fire in longleaf pine forests. Lightning density, however does not equate with fire ignitions. Only certain types of lightning strikes will generate enough heat for ignition and these must be accompanied by fuel moisture level sufficiently low to allow ignition and subsequent minimal amounts of precipitation or circumstances to allow for fire spread. Two ignitions occurred in stands over the course of the study. The first fire in September 1994 burned a small area around the tree and then was put out by the rainfall from the storm. The second ignition happened in March 1999 and burned about 1 ha before being put out by a National Forest fire control crew.

Management Implications

The stands used for this study have been under a long-term prescribed burning program for 30 years, which has included both dormant season and growing season burns during the last 20 years on a 3-year fire return interval. The mortality data from this study shows that prescribed burning kills very few trees in healthy longleaf pine stands.

Lightning disturbance can give us some clues in development of silvicultural management system that follow natural disturbance patterns. Uneven-aged management of sandhills longleaf could use a combination of single tree and group selection harvest with 20 percent taken to create new gaps, 50 percent harvested to expand existing gaps and 30 percent as single trees within the forest matrix as a starting guide. This should only be applied to stands with a healthy understory dominated by grasses and forbs. Do not create openings in stands with understories dominated by woody species, because this will release this woody competition while removing the overstory needle-fall needed to carry the fire necessary to control it.

The proper season for burning longleaf pine is still being debated. While lightning occurrence can give some indication of natural fire, as discussed above, lightning does not equate to fire. This scope of this study is too small to produce reliable data on ignition probabilities by season. Data for the entire 4000 ha Riverside Island, where two of the study stands were located, was obtained from National Forest records. Over a 14-year period ending in 2003, there were six lightning fires with one each in February, May, and August and three in June. This supports the contention that most fires likely occurred historically during the early growing season, May and June, but it also shows there was a long fire season.